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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

PCG0245 – CELLULAR REPRODUCTION AND GENETICS
(Foundation in Life Sciences)

10 MARCH 2017
3.00 p.m - 5.00 p.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of **8** printed pages excluding the cover page with **5** structured questions.
2. Answer **ALL** questions.
3. Distribution of marks for each section/question is given.

STRUCTURED QUESTIONS [100 MARKS]

Instructions: Answer all questions. Write your answers in the answer booklet.

Question 1 (20 marks)

a. **Figure 1** shows a diagram of an animal cell undergoing meiosis.
    i.   Identify the stage of meiosis shown in **Figure 1**.   (1 mark)
    ii.   Describe the main events that occur during this stage.   (2 marks)
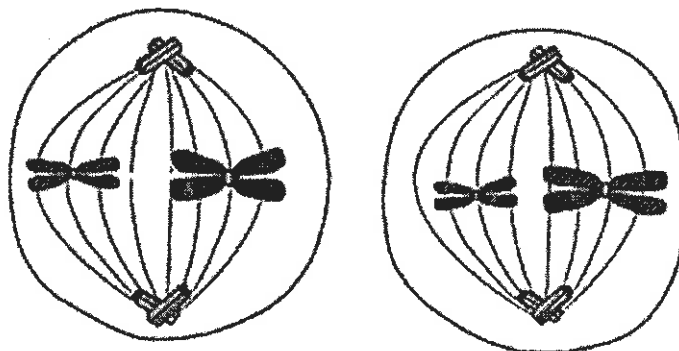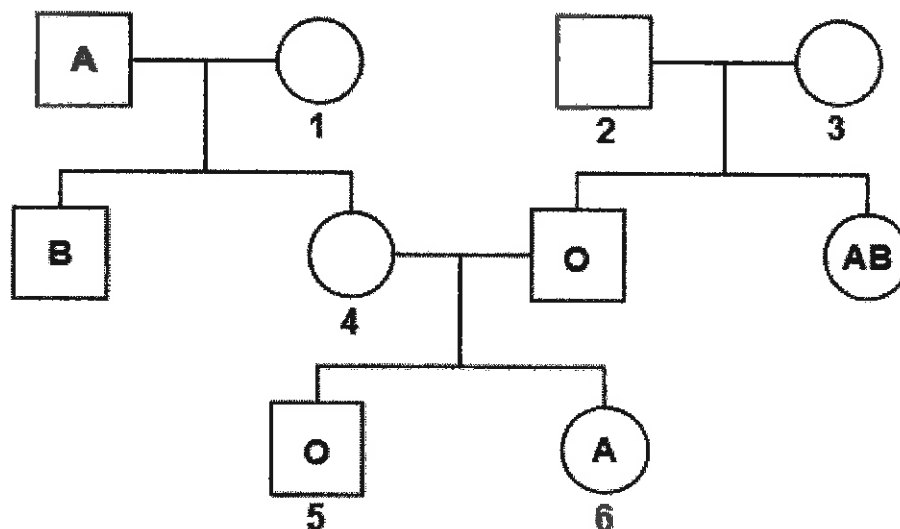   iii. Explain one way in which meiosis leads to variation.   (4 marks)

Figure 1

b. Briefly explain the terms below.
    i.   Metastasis
    ii.   Benign tumor
    iii. Carcinomas

                                                                          (3 marks)

c. In sheep, the characteristics of normal fur is controlled by a dominant allele R and
    non-uniform fur is controlled by a recessive allele r. In a population of 1000 sheep
    that mate randomly, it is found that 250 sheep have non-uniform fur.
    i.   Calculate the frequency of recessive allele in the population.   (2 marks)
    ii.   Calculate the frequency of the sheep in the population which have
          heterozygous Rr genotype.   (3 marks)
    iii. Calculate the number of sheep in the population with homozygous dominant
          genotype.   (3 marks)

d. According to Hardy-Weinberg law, genetic equilibrium occurs if certain conditions
    are met. State two conditions that must be met in Hardy-Weinberg law. (2 marks)
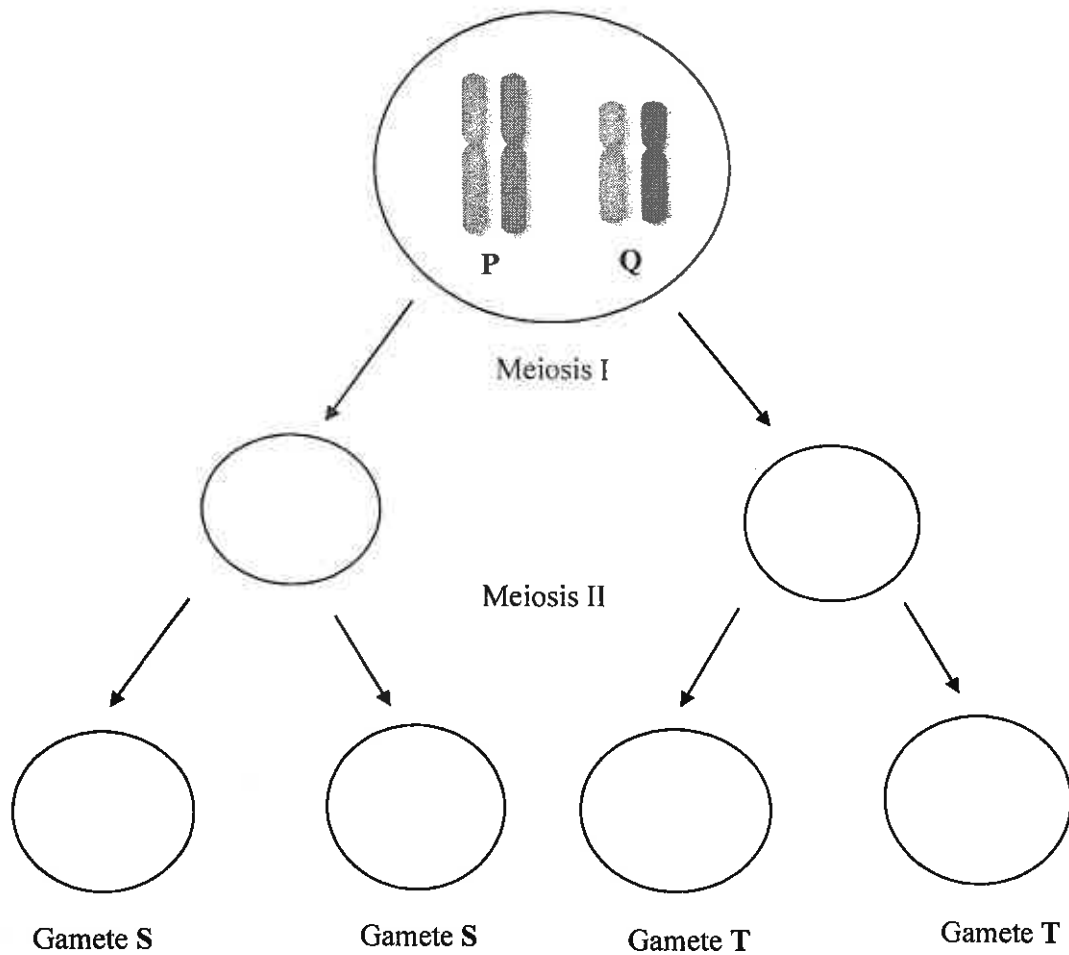
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Question 2 (20 marks)

a. In humans, hemophilia is a sex-linked condition and normal blood clotting (H) is dominant to the condition of hemophilia (h). A woman with hemophilia marries a normal man. What is the probability of them having children with hemophilia?

(4 marks)

b. A plant produces fruit that are either white or yellow in colour and are either shaped like a disc or a sphere. The dominant phenotypes are white and disc-shaped fruit. Using the symbols **A** for white and **a** for yellow and **B** for disc and **b** for sphere, draw a Punnett square to show what proportion of offspring will have yellow and sphere-shaped fruit if a white and disc-shaped fruit plant, heterozygous for both genes, is self-fertilised.

(5 marks)

c. **Figure 2** shows a pedigree diagram of the inheritance of the ABO blood group system. The blood group of some of the individuals is given in the pedigree. State the phenotype and genotype for individuals 1, 2, 3 and 4.   (4 marks)
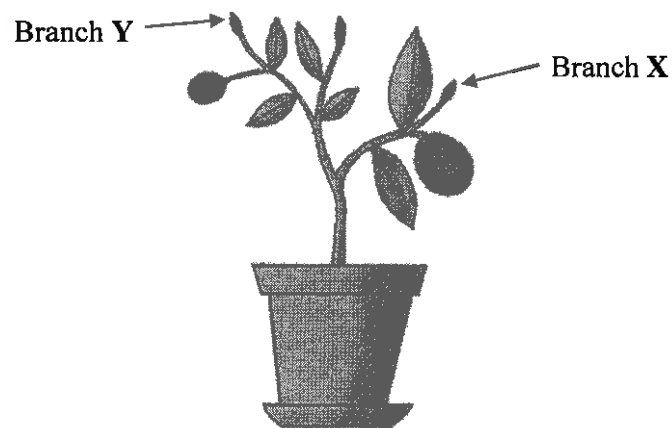

Figure 2

d. **Figure 3** shows a pair of chromosome P and a pair of chromosome Q. Chromosome P will produce gamete S and chromosome Q will produce gamete T.

    i. During the formation of gametes, the failure of sister chromatids or a pair of homologous chromosomes to separate causes a mutation which changes the number of chromosomes. Name the phenomenon.   (1 mark)

    ii. If process d(i) above occurs involving the pair of chromosome P during meiosis I, what is the number of chromosome P if gametes S and T are fertilized by normal gametes?   (2 marks)
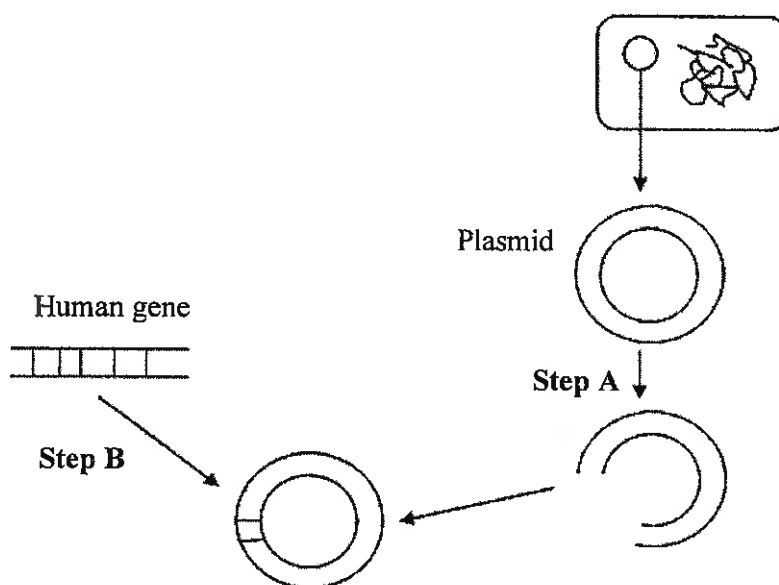
Continued...

Figure 3

e. **Figure 4** shows a potted diploid flowering plant. In an experiment, colchicine is applied onto the terminal bud of branch X. Suggest what would happen to the leaves of branch **X** and branch **Y** after several weeks. Give reasons for the answer given.

(4 marks)

Figure 4

Continued...

Question 3 (20 marks)

a. In a genetic engineering experiment, a human gene is inserted into a plasmid as shown in **Figure 5**.

    i.   What is the term that is used to describe the function of the plasmid in this experiment?   (1 mark)

    ii.   Name the type of enzyme used at step **A** to cut the DNA.   (1 mark)

    iii.   State one method by which a copy of the human gene can be produced.

                                                                           (1 mark)

    iv.   Name the type of enzyme used at step **B** and state its function.   (2 marks)

    v.   Genetically engineered human insulin is now used in the treatment of diabetes. State three advantages of the use of this type of insulin.   (3 marks)

Human gene

Plasmid

Step A

Step B

Figure 5

b. The polymerase chain reaction is a process which can be carried out in a laboratory to replicate DNA. **Figure 6** shows the main stages involved in the polymerase chain reaction.

    i.   Explain why DNA is heated to 95°C.   (1 mark)

    ii.   What is the role of a primer in this process?   (1 mark)

    iii.   Why do we need DNA polymerase in this process?   (1 mark)

    iv.   How many DNA molecules will have been produced from one molecule of DNA after 6 complete cycles?   (1 mark)

    v.   Suggest one use of the polymerase chain reaction.   (1 mark)

    vi.   Give two ways in which the polymerase chain reaction differs from the process of transcription.   (2 marks)

Continued...

1. DNA is heated to 95°C for 5 minutes	→	2. Primers, DNA molecules and DNA polymerase are added

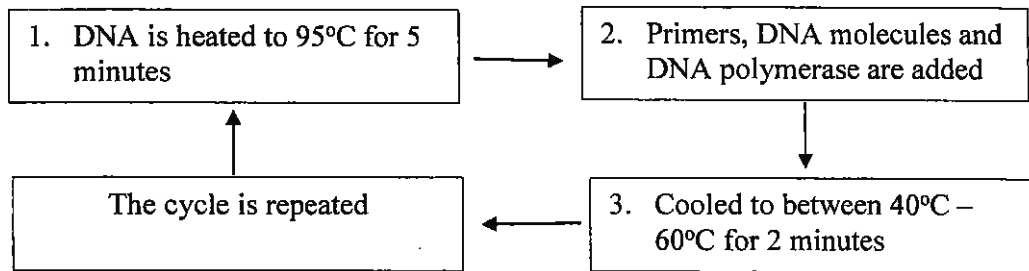| The cycle is repeated	←	3. Cooled to between 40°C – 60°C for 2 minutes

Figure 6

c. Mrs. Smith has a baby named Tyra. She believes one of the two men can be the father of her child. A paternity test is done and the results are shown in **Figure 7**.

   i.   Which of the two men is baby Tyra's father? Explain your answer.

   (2 marks)

   ii.   What role does the electric field plays in the separation of the DNA fragments into visible bands on the gel?   (3 marks)
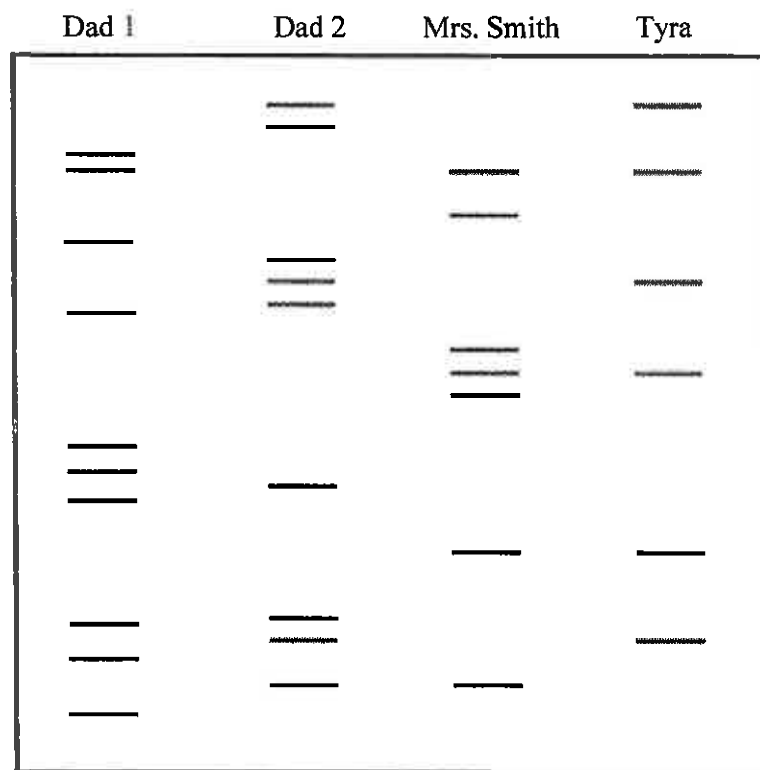
Dad 1   Dad 2   Mrs. Smith   Tyra

Figure 7

Question 4 (20 marks)

a. The black mamba is a poisonous snake. Its poison contains a toxin. **Figure 8** shows a part of the base sequence of the mRNA that codes for this toxin.

    i.   Write the base sequence of the anticodon for the mRNA in **Figure 8**.

                                              (1 mark)

    ii.   Write the base sequence of DNA from which the mRNA was transcribed.

                                              (1 mark)

    iii.   The length of the section of DNA that codes for the complete toxin is longer than the mRNA used for translation. Explain why.   (3 marks)

    iv.   Assume that the toxin produced was 175 amino acids long, corresponding to a 528 bases of mRNA. Explain why a protein that is 175 amino acids long is coded by 528 bases of mRNA.   (3 marks)

ACG AUG GCU GUU

Figure 8

b. **Figure 9** shows the *lac* operon structure in *E.coli*.

    i.   What is meant by an operon?   (1 mark)

    ii.   Name structures **X** and **Y**.   (2 marks)

    iii.   What will happen if lactose is present in the medium?   (4 marks)

Figure 9

c. **Figure 10** shows a stage in the synthesis of a type of protein in a cell.

    i.   Name bond X.   (1 mark)

    ii.   Identify the stage of protein synthesis shown in **Figure 10**.   (1 mark)

    iii.   What is the function of P site in the ribosome?   (1 mark)

    iv.   Explain how tRNA is involved in the assembly of the correct sequence of amino acids in the protein.   (2 marks)
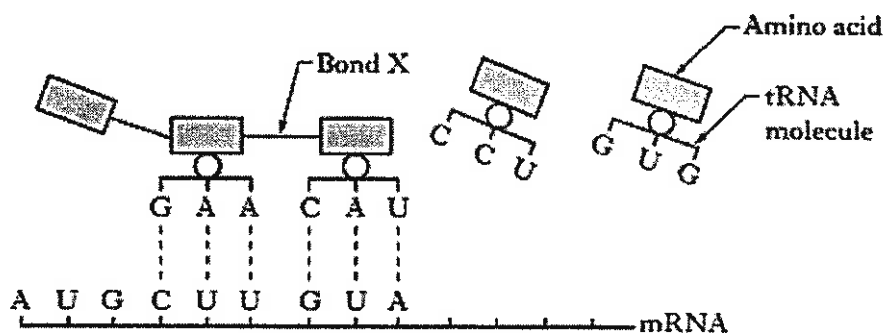
Figure 10

Continued...

Question 5 (20 marks)

a. **Figure 11** shows the concentration of FSH and LH in plasma during a woman's menstrual cycle. **Figure 12** shows the concentration of two other hormones **X** and **Y** produced in the ovary during the same menstrual cycle.

     i.   State one function of each of the hormones listed below:
- FSH
- LH

                                                    (2 marks)

     ii.   Based on **Figure 12**, name hormones **X** and **Y**.   (2 marks)

     iii.   Based on the two graphs in **Figure 11** and **Figure 12**, on which day did ovulation occur in this woman's menstrual cycle? Explain the evidence for your answer.   (3 marks)

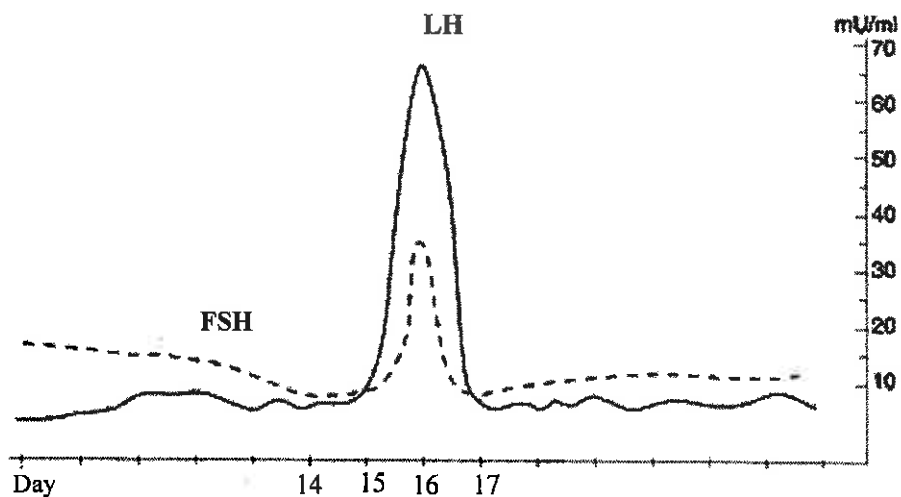   iv.   Explain why ovulation will not occur when a woman is pregnant. (2 marks)
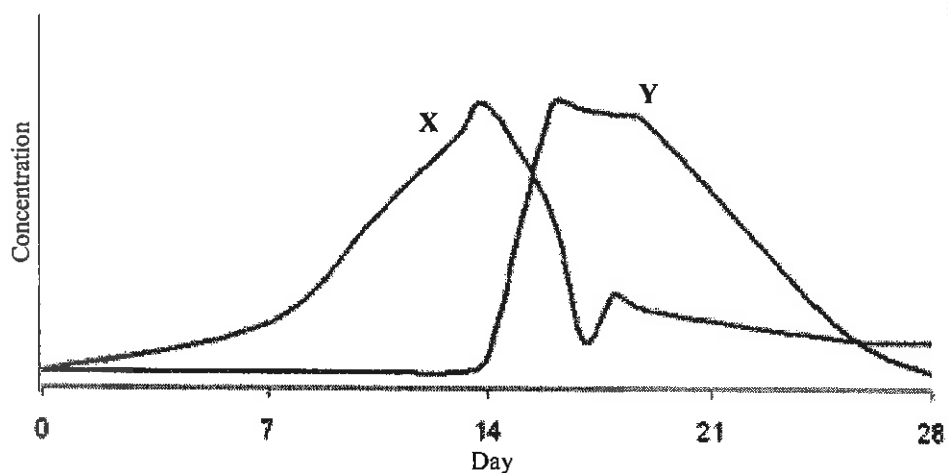
Figure 11

Figure 12

b. **Figure 13** shows an embryo sac of a plant.
  i.   Name the structures labeled **A** and **B**.   (2 marks)
  ii.   During fertilization, a process that is specific to plants takes place. Name and explain this process.   (3 marks)
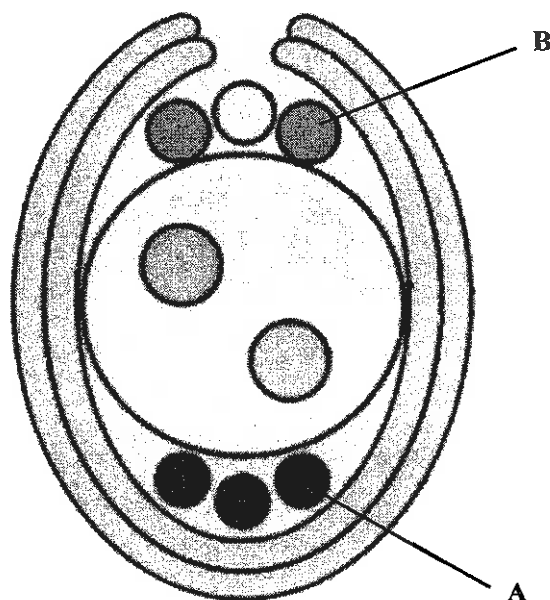

Figure 13

c. **Table 1** shows the result of a group of students obtained from their research on an arthropod's growth pattern starting from the day it hatches until it became an adult.
  i.   What is the type of growth pattern shown by the arthropod?   (1 mark)
  ii.   How many instars have occurred?   (1 mark)
  iii. Explain the growth process of this arthropod.   (4 marks)

Days	1	6	7	14	15	22	23	31	32	40	42	50
Size (cm)	1.3	1.3	1.7	1.7	2.3	2.3	2.8	2.8	3.4	3.4	4.4	4.4

Table 1

End of Paper